Newton Power Station

Newton, Illinois

Evaluation of Compliance with the 1-hour NAAQS for SO_2

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Conducted by:

Steven Klafka, P.E., BCEE

Wingra Engineering, S.C.

Madison, Wisconsin

1. Introduction

Wingra Engineering, S.C. was hired by Sierra Club to conduct an air modeling impact analysis to help the U.S. Environmental Protection Agency (USEPA), state and local air agencies identify facilities that are likely causing exceedances of the 1-hour sulfur dioxide (SO_2) national ambient air quality standard (NAAQS). This document describes the results and procedures for an evaluation conducted for the Newton Power Station located in Newton, Illinois.

To ensure the modeling analysis reflected the cumulative concentration of SO_2 emissions, it included the Rain CII Carbon LLC facility in Robinson, Illinois, which is an additional source of SO_2 emissions located within 50 kilometers of the Newton Power Station.

The dispersion modeling analysis predicted ambient air concentrations for comparison with the 1-hour SO_2 NAAQS. The modeling was performed using the most recent version of AERMOD, AERMET, and AERMINUTE, with data provided to Sierra Club by regulatory air agencies or obtained through other publicly-available sources as documented below. The analysis was conducted in adherence to all available USEPA guidance for evaluating source impacts on attainment of the 1-hour SO_2 NAAQS via aerial dispersion modeling, including the AERMOD Implementation Guide; USEPA's Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010; modeling guidance promulgated by USEPA in Appendix W to 40 CFR Part 51; USEPA’s March 2011 Modeling Guidance for SO_2 NAAQS Designations;[1] and, USEPA’s December 2013 SO_2 NAAQS Designations Technical Assistance Document.[2]

2. Compliance with the 1-hour SO_2 NAAQS

2.1 1-hour SO_2 NAAQS

The 1-hour SO_2 NAAQS takes the form of a three-year average of the 99th-percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 75 parts per billion (ppb).[3] Compliance with this standard was verified using USEPA’s AERMOD air dispersion model, which produces air concentrations in units of $\mu g/m^3$. The 1-hour SO_2 NAAQS of 75 ppb equals 196.2 $\mu g/m^3$, and this is the value used for determining whether modeled impacts exceed the NAAQS.[4] The 99th-percentile of the annual distribution of daily maximum 1-hour concentrations

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[1] http://www.epa.gov/scram001/so2_modeling_guidance.htm
[2] http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
[3] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010.
[4] The ppb to $\mu g/m^3$ conversion is found in the source code to AERMOD v. 14134, subroutine Modules. The conversion calculation is 75/0.3823 = 196.2 $\mu g/m^3$.

corresponds to the fourth-highest value at each receptor for a given year.

2.2 Modeling Results

Model results for both sources included in the analysis of SO_2 are summarized in Table 1. Results are provided for each source alone, and for both sources combined.

Modeling results for Newton Power Station and the Rain CII Carbon LLC facility are summarized in Table 1. It was determined that based on either current allowable emissions or measured actual emissions, these facilities are estimated to create downwind SO_2 concentrations which exceed the 1-hour NAAQS.

More specifically, the modeling results presented in Table 1, show exceedances of the NAAQS by facility allowable and actual emissions. "Allowable" is the peak emission rate from each unit as approved by the current air quality operation permit for the facility. "Actual" are the measured emissions for each hour between January 1, 2012 and December 31, 2014 as taken from USEPA *Air Markets Program Data*.[5]

Air quality impacts in Illinois are based on a background concentration of 20.9 µg/m^3. This is the 2011-13 design value for LaSalle County, Illinois - the lowest measured background concentration in the state. This is the most recently available design value. See Section 5 for further discussion of the background concentrations used for this analysis.

Table 1 - SO_2 Modeling Results for Newton Power Station Modeling Analysis

Emission Rates	Averaging Period	99th Percentile 1-hour Daily Maximum (µg/m^3)				Complies with NAAQS?
		Impact	Background	Total	NAAQS	
Allowable	Newton	273.6	20.9	294.5	196.2	No
Actual		87.5	20.9	108.4	196.2	Yes
Allowable	Rain CII Carbon	123.0	20.9	143.9	196.2	Yes
Actual		514.9	20.9	535.8	196.2	No
Allowable	Both	273.9	20.9	294.8	196.2	No
Actual		514.9	20.9	535.8	196.2	No

[5] http://ampd.epa.gov/ampd/

The emissions used for the modeling analysis are summarized in Table 2.

Table 2 - Modeled SO_2 Emissions from Newton Power Station [6]

Stack ID	Unit ID	Allowable Emissions 1-hour Average (lbs/hr)
S01	Boiler NB-1	6,600
S02	Boiler NB-2	6,600
Stack Total	All Units	13,200
S01	Kiln 1	679.6
S02	Kiln 2	679.6
Rain CII Carbon	Both Kilns	1,359.2
All	All	14,559.2

Based on the modeling results, Table 3 provides the necessary emission reductions from current allowable rates necessary to achieve compliance with the 1-hour NAAQS. This estimate is based on the impact of all sources, but assumes that only the Newton Power Station achieves the reductions necessary to comply with the NAAQS.

This assumes a one-hour averaging period for the emission rate, and that the emission rate is binding at all times. However, it is extremely likely that this limit is too high to protect the NAAQS, given the conservative aspects of this modeling protocol. For example, startup or shutdown periods were not evaluated. During these periods, decreased gas velocities and temperatures may lead to greater ambient impacts at ground level. Further, the hypothetical emission limitation in Table 3 would allow the Newton Power Station to consume the entire NAAQS, leaving little to no room for any other source of SO_2 in the area. No consideration has been given to other sources aside from the Rain CII Carbon LLC facility, and no margin of safety has been included in the hypothetical emission limitation.

Table 3 - Required Emission Reductions for Compliance with the 1-hour NAAQS for SO_2

Acceptable Impact (NAAQS - Background) 99th Percentile 1-hour Daily Max ($\mu g/m^3$)	Required Total Facility Reduction Based on Allowable Emissions (%)	Required Total Facility Emission Rate (lbs/hr)	Required Total Facility 1-hour Average Emission Rate (lbs/mmbtu)
175.3	36%	8,448.2	0.77

[6] SO_2 emissions from Boilers NB-1 and NB-2 at Newton are limited to 1.2 lbs/mmbtu. Operating Permit for ID No. 079808AAA issued September 29, 2005 by Illinois EPA. Allowable emissions from Rain CII Carbon LLC were obtained from the Illinois EPA, Annual Emissions Report, 2014.

Predicted exceedances of the 1-hour NAAQS for SO_2 based on allowable emissions extend throughout the region to a maximum distance of 16 kilometers.

Figure 1 shows the extent of NAAQS violations based on allowable emissions for both sources.

Figure 2 shows the extent of NAAQS violations based on actual hourly emissions for both sources.

2.3 Conservative Modeling Assumptions

A dispersion modeling analysis requires the selection of numerous parameters which affect the predicted concentrations. For the enclosed analysis, several parameters were selected which under-predict facility impacts.

Assumptions used in this modeling analysis which likely under-estimate concentrations include the following:

- Allowable emissions are based on a limitation with an averaging period which is greater than the 1-hour average used for the SO_2 air quality standard. Emissions and impacts during any 1-hour period may be higher than assumed for the modeling analysis.
- No consideration of facility operation at less than 100% load. Stack parameters such as exit flow rate and temperature are typically lower at less than full load, reducing pollutant dispersion and increasing predicted air quality impacts.
- No consideration of building or structure downwash. These downwash effects typically increase predicted concentrations near the facility.
- Except for Rain CII Carbon LLC, no consideration of off-site sources. These other sources of SO_2 will increase the predicted impacts.

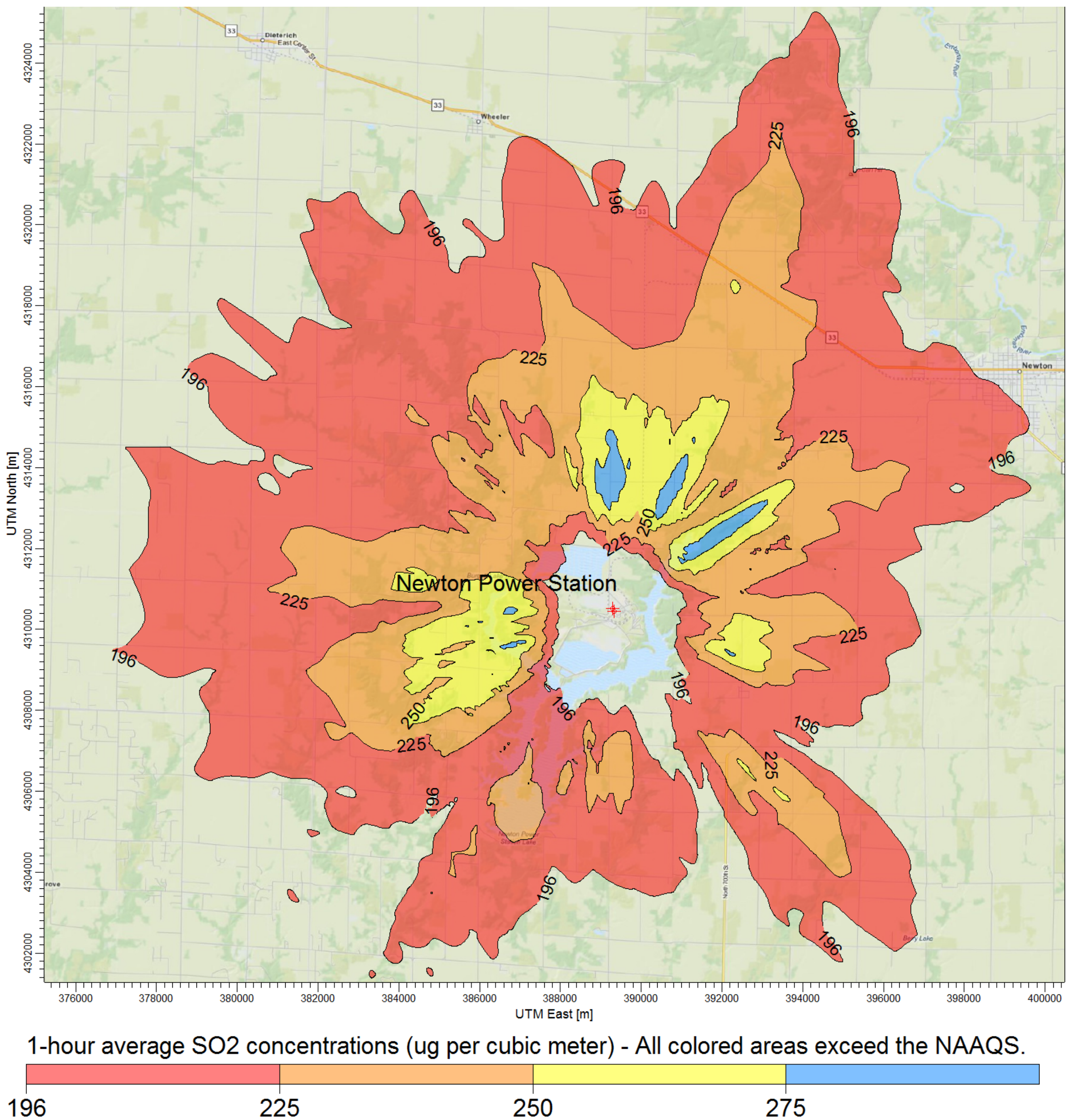

Figure 1 - Regional View of Impacts Based on Allowable Emissions from Both Sources

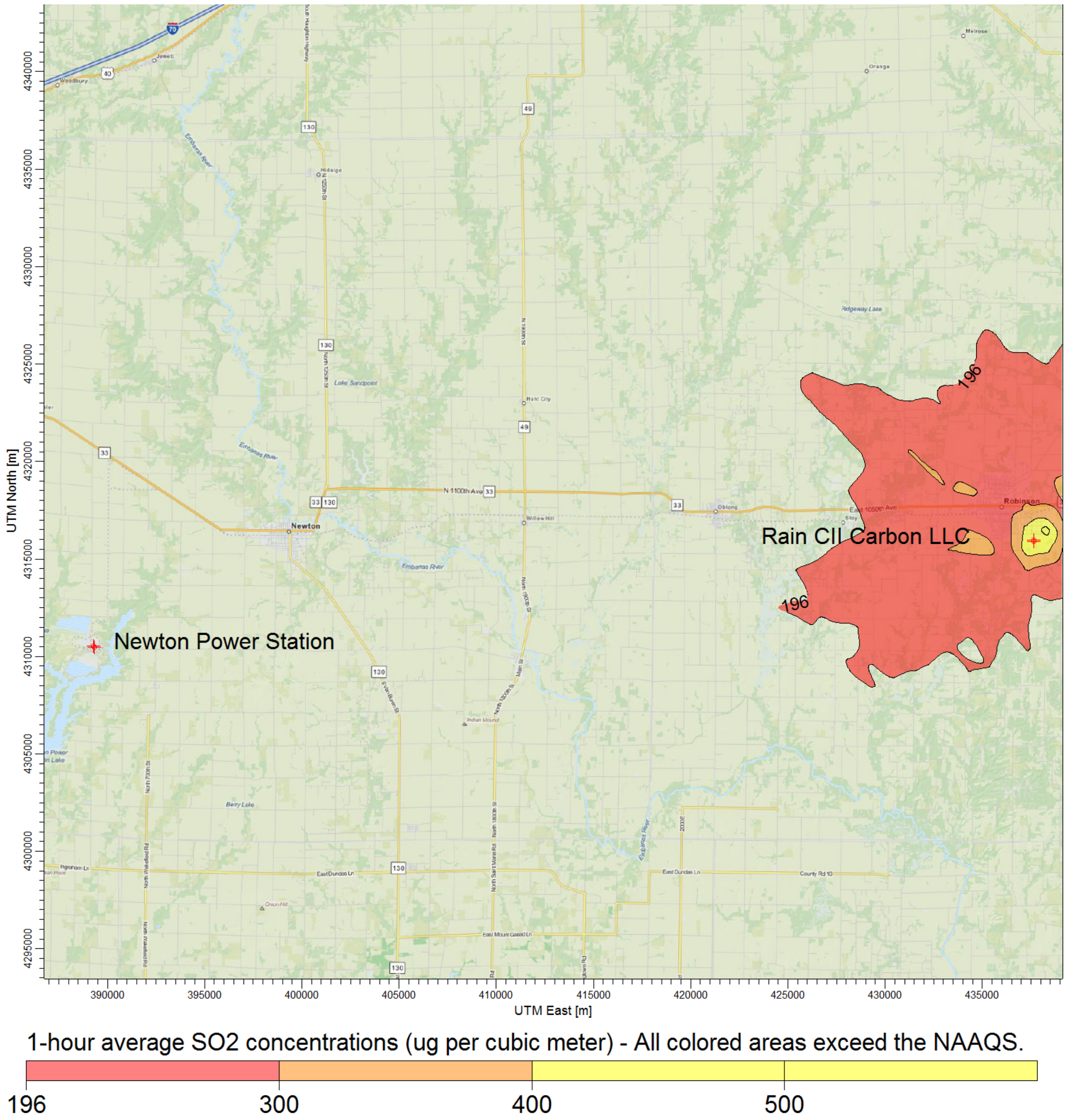

Figure 2 - Regional View of Impacts Based on Actual Emissions from Both Sources for the 2012-14 Period

3. Modeling Methodology

3.1 Air Dispersion Model

The modeling analysis used USEPA's AERMOD program, v. 14134. AERMOD, as available from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, was used in conjunction with a third-party modeling software program, *AERMOD View*, sold by Lakes Environmental Software.

3.2 Control Options

The AERMOD model was run with the following control options:

- 1-hour average air concentrations
- Regulatory defaults
- Flagpole receptors

To reflect a representative inhalation level, a flagpole height of 1.5 meters was used for all modeled receptors. This parameter was added to the receptor file when running AERMAP, as described in Section 4.4.

An evaluation was conducted to determine if the modeled facility was located in a rural or urban setting using USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.[7] For urban sources, the URBANOPT option is used in conjunction with the urban population from an appropriate nearby city and a default surface roughness of 1.0 meter. Methods described in Section 4.1 were used to determine whether rural or urban dispersion coefficients were appropriate for the modeling analysis.

3.3 Output Options

The AERMOD analysis was based on three years of recent meteorological data. The modeling analyses used one run with three years of sequential meteorological data from 2012-2014. Consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations, AERMOD provided a table of fourth-high 1-hour SO_2 impacts concentrations consistent with the form of the 1-hour SO_2 NAAQS.[8]

Please refer to Table 1 for the modeling results.

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[7] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.
[8] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 24-26.

4. Model Inputs

4.1 Geographical Inputs

The “ground floor” of all air dispersion modeling analyses is establishing a coordinate system for identifying the geographical location of emission sources and receptors. These geographical locations are used to determine local characteristics (such as land use and elevation), and also to ascertain source to receptor distances and relationships.

The Universal Transverse Mercator (UTM) NAD83 coordinate system was used for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. Stack locations were obtained from facility permits and prior modeling files provided by the state regulatory agency. The stack locations were then verified using aerial photographs.

The facility was evaluated to determine if it should be modeled using the rural or urban dispersion coefficient option in AERMOD. A Geographic Information System (GIS) was used to determine whether rural or urban dispersion coefficients apply to a site. Land use within a three-kilometer radius circle surrounding the facility was considered. USEPA guidance states that urban dispersion coefficients are used if more than 50% of the area within 3 kilometers has urban land uses. Otherwise, rural dispersion coefficients are appropriate.[9]

USEPA’s AERSURFACE v. 13016 was used to develop the meteorological data for the modeling analysis. This model was also used to evaluate surrounding land use within 3 kilometers. Based on the output from the AERSURFACE, approximately 0.3% of surrounding land use around the modeled facility was of urban land use types including Type 21 – Low Intensity Residential, Type 22 – High Intensity Residential and Type 23 – Commercial / Industrial / Transportation.

This is less than the 50% value considered appropriate for the use of urban dispersion coefficients. Based on the AERSURFACE analysis, it was concluded that the rural option would be used for the modeling summarized in this report. Please refer to Section 4.5.3 for a discussion of the AERSURFACE analysis.

[9] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005, Section 7.2.3.

4.2 Emission Rates and Source Parameters

The modeling analyses only considered SO_2 emissions from the Newton and Rain CII Carbon facilities. Other off-site sources were not considered. Concentrations were predicted for the scenarios shown in Tables 1 and 2:

1) allowable emissions based on the current permit issued by the regulatory agency, and

2) actual hourly emissions measured each hour between January 1, 2012 and December 31, 2014 as taken from USEPA *Air Markets Program Data*.[10]

Stack parameters and emissions used for the modeling analysis are summarized in Table 4.

Table 4 – Facility Stack Parameters and Emissions [11]

Facility	Newton		Rain CII Carbon	
Stack	S01	S02	T01	T02
Description	Boiler NB-1	Boiler NB-2	Kiln 1	Kiln 2
X Coord. [m]	389292	389331	437643	437639
Y Coord. [m]	4310519	4310453	4315970	4315893
Base Elevation [m]	165.48	165.73	164.59	165.65
Release Height [m]	161.54	161.54	45.7	45.7
Gas Exit Temperature [°K]	435.928	435.928	1374.8	1403.2
Gas Exit Velocity [m/s]	33.587	39.956	16.5	19.5
Inside Diameter [m]	6.401	6.096	3.05	3.05
Allowable Emission Rate [g/s]	831.6	831.6	85.63	85.63
Actual Emission Rate [g/s]	-	-	-	-

The above stack parameters and emissions were obtained from regulatory agency documents and databases identified in Section 2.2. The analysis was conducted based on 100% operating load using maximum exhaust flow rates and temperatures. Operation at less than full capacity loads was not considered. This assumption tends to under-predict impacts since stack parameters such as exit flow rate and temperature are typically lower at less than full load, reducing pollutant dispersion and increasing predicted air quality impacts. Stack location, height and diameter were verified using aerial photographs, and flue gas flow rate and temperature were verified using combustion calculations.

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[10] http://ampd.epa.gov/ampd/

[11] Stack parameters for Newton were obtained from the annual survey compiled by the U.S. Energy Information Administration. http://www.eia.gov/electricity/data/eia860/. Stack parameters for Rain CII Carbon LLC were obtained from the following report: RTP Environmental Associates, Inc., 1-hour SO2 National Ambient Air Quality Standards Analysis for Marthon Refinery in Robinson, Illinois, February 9, 2015.

4.3 Building Dimensions

No building dimensions or prior downwash evaluations were available. Therefore this modeling analysis did not address the effects of downwash and this may under-predict impacts.

4.4 Receptors

For Newton Power Station, three receptor grids were employed:

1. A 100-meter Cartesian receptor grid centered on Newton Power Station and extending out 5 kilometers.
2. A 500-meter Cartesian receptor grid centered on Newton Power Station and extending out 10 kilometers.
3. A 1,000-meter Cartesian receptor grid centered on Newton Power Station and extending out 50 kilometers. 50 kilometers is the maximum distance accepted by USEPA for the use of the AERMOD dispersion model.[12]

A flagpole height of 1.5 meters was used for all these receptors.

Elevations from stacks and receptors were obtained from National Elevation Dataset (NED) GeoTiff data. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. These elevations were extracted from 1 arc-second (30 meter) resolution NED files. The USEPA software program AERMAP v. 11103 is used for these tasks.

4.5 Meteorological Data

To improve the accuracy of the modeling analysis, recent meteorological data for the 2012-2014 period were prepared using the USEPA's program AERMET which creates the model-ready surface and profile data files required by AERMOD. Required data inputs to AERMET included surface meteorological measurements, twice-daily soundings of upper air measurements, and the micrometeorological parameters surface roughness, albedo, and Bowen ratio. One-minute ASOS data were available so USEPA methods were used to reduce calm and missing hours.[13] The USEPA software program AERMINUTE v. 14237 is used for these tasks.

This section discusses how the meteorological data was prepared for use in the 1-hour SO_2 NAAQS

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[12] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, Section A.1.(1), November 9, 2005.

[13] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, p. 19.

modeling analyses. The USEPA software program AERMET v. 14134 is used for these tasks.

4.5.1 Surface Meteorology

Surface meteorology was obtained for Evansville Regional Airport located near the Newton Power Station. Integrated Surface Hourly (ISH) data for the 2012-2014 period were obtained from the National Climatic Data Center (NCDC). The ISH surface data was processed through AERMET Stage 1, which performs data extraction and quality control checks.

4.5.2 Upper Air Data

Upper-air data are collected by a "weather balloon" that is released twice per day at selected locations. As the balloon is released, it rises through the atmosphere, and radios the data back to the surface. The measuring and transmitting device is known as either a radiosonde, or rawindsonde. Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed, and wind direction. The upper air data were processed through AERMET Stage 1, which performs data extraction and quality control checks.

For Newton Power Station, the concurrent 2012-2014 upper air data from twice-daily radiosonde measurements obtained at the most representative location were used. This location was the Lincoln, Illinois measurement station. These data are in Forecast Systems Laboratory (FSL) format and were downloaded in ASCII text format from NOAA's FSL website.[14] All reporting levels were downloaded and processed with AERMET.

4.5.3 AERSURFACE

AERSURFACE is a program that extracts surface roughness, albedo, and daytime Bowen ratio for an area surrounding a given location. AERSURFACE uses land use and land cover (LULC) data in the U.S. Geological Survey's 1992 National Land Cover Dataset to extract the necessary micrometeorological data. LULC data was used for processing meteorological data sets used as input to AERMOD.

AERSURFACE v. 13016 was used to develop surface roughness, albedo, and daytime Bowen ratio values in a region surrounding the meteorological data collection site. AERSURFACE was used to develop surface roughness in a one kilometer radius surrounding the data collection site. Bowen ratio and albedo was developed for a 10 kilometer by 10 kilometer area centered on the meteorological data collection site. These micrometeorological data were processed for seasonal periods using 30-degree sectors.

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[14] Available at: http://esrl.noaa.gov/raobs/

4.5.4 Data Review

Missing meteorological data were not filled as the data file met USEPA's 90% data completeness requirement.[15] The AERMOD output file shows there were 0.75% missing data.

To confirm the representativeness of the airport meteorological data, the surface characteristics of the airport data collection site and the modeled source location were compared. Since the Evansville Regional Airport is located close to Newton Power Station, this meteorological data set was considered appropriate for this modeling analysis.[16] This weather station provided high quality surface measurements for the most recent 3-year time, and had similar land use, surface characteristics, terrain features and climate. Finally, Illinois EPA staff were contacted concerning the selection of meteorological stations and confirmed the use of these stations as appropriate for the Newton Power Station.[17]

5. Background SO_2 Concentrations

Background concentrations were determined consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations.[18, 19] To preserve the form of the 1-hour SO_2 standard, based on the 99th percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the number of years modeled, the background fourth-highest daily maximum 1-hour SO_2 concentration was added to the modeled fourth-highest daily maximum 1-hour SO_2 concentration.[20] Background concentrations were based on the 2011-13 design value measured by the ambient monitors located in Illinois.[21]

6. Reporting

All files from the programs used for this modeling analysis are available to regulatory agencies. These include analyses prepared with AERSURFACE, AERMET, AERMAP, and AERMOD.

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[15] USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 to 5-5.
[16] USEPA, AERMOD Implementation Guide, March 19, 2009, pp. 3-4.
[17] Email Correspondence, M. Will – Illinois EPA to S. Klafka – Wingra Engineering, S.C., Request for IEPA Dispersion Modeling Meteorology, May 20, 2015.
[18] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 20-23.
[19] USEPA, SO_2 NAAQS Designations Modeling Technical Assistance Document, Dec. 2013, section 8.1, pp 27-28.
[20] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010, p. 3.
[21] http://www.epa.gov/airtrends/values.html